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Diagnostic performance, user acceptability, and safety of unsupervised SARS-CoV-2 rapid antigen detecting tests performed at home

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Highlights

- The self-RADTs had sensitivities of 65.7 % and 62.1%, and specificities of 100%
- Self-RADT sensitivities appeared higher among symptomatic participants.
- Two out of every three participants preferred the self-RADT over the PCR test

Abstract

Background: One strategy for reducing spread of COVID-19 is to contain the infection with broad screening, isolate infected individuals, and trace contacts. This strategy requires widely available, reliable SARS-CoV-2 testing. To increase testing, rapid antigen detection tests (RADTs) were developed for self-sampling, self-testing, and self-interpretation. This study examined diagnostic performance, user acceptability, and safety of nasal self-RADTs, compared to PCR testing.

Methods: Self-RADT kits were distributed at a public COVID-19 test center in Aarhus, Denmark or delivered to participants. Participants reported test results and test preferences. During enrollment, participants reported occurrence and duration of symptoms consistent with COVID-19. Sensitivity and specificity of self-RADT, relative to oropharyngeal PCR testing, were calculated.

Results: Among 827 participants, 102 showed positive PCR test results. Sensitivities of the self-RADTs were 65.7% (95% CI: 49.2–79.2; DNA Diagnostic) and 62.1% (95% CI: 50.1–72.9; Hangzhou), and specificities were 100% (95% CI: 99.0–100; DNA Diagnostic) and 100% (95% CI: 98.9–100; Hangzhou). The sensitivities of both self-RADTs appeared higher in symptomatic participants than in asymptomatic participants. Two out of every three participants preferred self-RADT over PCR test.

***Conclusion*:** Self-performed RADTs were reliable, user acceptable, and safe among laypeople as supplement to professionally collected oropharyngeal PCR testing.

Keywords: SARS-CoV-2; Antigen test; Rapid test; COVID-19; Diagnostics; Self-testing

Introduction

Rapid antigen detection tests (RADTs) that can be used to self-test for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infections are available in several countries. However, few studies have examined the self-test application of RADTs. Self-tests require the individual to collect a specimen, conduct a RADT protocol, and interpret the result without assistance (Foundation for Innovative New Diagnostics, 2021).

Currently, the gold-standard testing method for SARS-CoV-2 is a nasopharyngeal swab or a combined nasopharyngeal/oropharyngeal swab, followed by a reverse transcriptase polymerase chain reaction (RT-PCR) analysis. The standard SARS-CoV-2 test method in Denmark is a swab from the oropharynx, performed by a trained health care worker, and an RT-PCR analysis (Statens Serum Institut, 2021). The disadvantages of this approach are the high cost of the RT-PCR analysis, the long response time, the need for personnel to operate the COVID-19 test centers, and the risk of virus transmission to health care workers and other citizens at the test centers.

RADTs have a short response time and require little equipment and reagents for analysis. On the other hand, RADTs have lower sensitivities and specificities than the RT-PCR analysis. Nevertheless, the sensitivity of RADTs appears to correlate with the viral load (Corman et al., 2021; Krüger et al., 2020; Osmanodja et al., 2021). The viral load is estimated to be highest 2-3 days after symptom onset and is probably the timepoint when most infectious (Ejima et al. 2021).

Nasopharyngeal swabs and self-swabs from the anterior nasal region have comparable sensitivities, when performed by professionals, particularly when the viral load is high (Hanson et al., 2020; Kojima et al., 2020; Lindner et al., 2021a, 2021b; McCulloch et al., 2020; Tsang et al., 2021; Tu et al., 2020). From a public health perspective, self-tests can offer advantages, when used to complement professionally administered PCR tests or RADTs. Self-tests can improve accessibility to testing, support early detection of infectious cases, and reduce further community transmission. Therefore, self-testing could enhance disease control, with prompt identification and isolation of infectious individuals (European Centre for Disease Prevention and Control, 2021).

The present study aimed to evaluate the sensitivity, specificity, user acceptability, and safety of two different nasal RADTs, when performed at home by participants, compared to an oropharyngeal swab performed by a trained health care worker and analyzed with RT-PCR.

Methods

Study design and participants

This study was a manufacturer-independent prospective study. We evaluated the diagnostic accuracy, user acceptability, and safety of two RADTs, when performed unsupervised by participants at home. For comparison, the participants underwent an oropharyngeal swab, performed by a health care worker at the ambulatory public COVID-19 test center of Aarhus University Hospital, Denmark, and the sample was analyzed with RT-PCR. In addition, some participants that were recruited onsite were tested with a nasopharyngeal RADT performed by a health care worker.

Participants were eligible for inclusion, when they were ≥18 years old, had made an appointment for PCR testing at the public test center, were able to conduct the RADT within 72 hours (h) after their PCR test at the test center, and were able to understand written and spoken Danish. Participants were not eligible for inclusion if they had had a nose-bleed within 24 h prior to the RADT performance, any nose operation within four weeks prior to the execution of the RADT, or a previous infection with SARS-CoV-2. Previous infected individuals were not included because the PCR analysis can detect the virus weeks after an infection (Mallett et al., 2020).

Antigen tests

The primary tests evaluated in this study were two nasal RADTs: the COVID-19 Antigen Detection Kit (DNA Diagnostic A/S, Risskov, Denmark) and the SARS-CoV-2 Antigen Rapid Test (Hangzhou Immuno Biotech Co. Ltd, Hangzhou, China). In addition, we evaluated a nasopharyngeal RADT, known as the COVID-19 Antigen Rapid Test Device (Abbott Rapid Diagnostic Jena GmbH, Jena, Germany). The participants swabbed themselves in each nostril for 5 seconds. Hereafter the swab was mixed with buffer. Buffer with specimen was added to a test plate. For the test to be conclusive a line should appear after 10 min in the control area of the test plate. If a line appeared in the test area the test was positive, and no line indicated a negative result. Weak lines in the test area were also considered positive results. Both tests were validated prior to this study and were CE-marked.

Study procedures

Study participants were recruited either onsite, at the COVID-19 test center of Aarhus University Hospital, Denmark (onsite participants) or by telephone (offsite participants). Onsite participants had come to the test center for SARS-CoV-2 testing and expressed a willingness to try a self-test at home. These participants signed a written informed consent form at the center and were given a RADT kit to be performed at home. Offsite participants were recruited after they contacted the project group subsequent to receiving a positive result on a PCR test performed at the test center. These participants received a RADT kit delivered to their address with a written informed consent form, which they signed and returned digitally to the project group. Participants were enrolled during four periods. Onsite participants were enrolled from 21 January to 25 January, 2021, for both the DNA Diagnostic RADT and the Abbott RADT; and from 25 March to 4 April, 2021, for the Hangzhou RADT. Offsite participants were enrolled from 16 February, to 10 March, 2021, for the DNA Diagnostic RADT; and from 10 March to 31 March, 2021, for the Hangzhou RADT. All test kits contained a written, illustrated instruction pamphlet and a link to an online instruction video for self-sampling and self-testing. All instructions were translated into Danish from the manufacturers' instruction pamphlets. The RADT results were self-interpreted by participants and the interpretation was confirmed by the project team, based on photographs of the test plates that were sent by e-mail from the participants to the project inbox. Study participants were provided with a telephone number and a secure e-mail address for returning study-relevant material and for technical support. In case of a positive or inconclusive self-RADT result, participants were advised to call in for further instructions.

Standard reference RT-PCR

Samples for RT-PCR testing were obtained with oropharyngeal swabs. All PCR analyses for detecting SARS-CoV-2 RNA were performed by ISO standard accredited laboratories at the Department of Clinical Microbiology, Aarhus University Hospital or at the national reference laboratory at the Statens Serum Institute. Internationally approved PCR platforms were used. The result from the RT-PCR analysis was self-reported by each participant; however, consent was given for the project group to obtain the result from the laboratory, when necessary. At the time of participant enrollment, all citizens could make appointments for free PCR tests, and the response time was less than 48 h. The Danish government recommended that citizens should get a PCR test when they had been in close contact with a person infected with SARS-CoV-2, when they had experienced symptoms consistent with COVID-19, and when they were about to undergo hospitalization or medical procedures etc. In Denmark, RADTs were recommended for routine testing for all individuals in populations with a particularly high incidence of SARS-CoV-2 and for individuals that received a notification from the COVID-19 app "SmitteStop" (Sundhedsstyrelsen, 2021).

Additional data collection

During enrollment, participants were asked to describe the reason for making an appointment for PCR testing, their symptoms, and the symptom duration. Additionally, participants were asked about the number of COVID-19 vaccine injections they had received and whether they had a health professional background. When reporting their self-RADT results, participants were asked which test they preferred and why. Besides, 355 participants were asked whether performing the RADT caused nose bleeding.

Statistical analysis

Data were collected and managed with Research Electronic Data Capture (REDCap) tools. Statistical analyses were performed in Stata/MP 17.0. Sensitivity and specificity, with 95% confidence intervals (95% CIs), were calculated for self-RADTs with the Wilson test. Those results were compared to the sensitivity and specificity of the reference standard PCR test. Inconclusive RADT or PCR test results were not included in the statistical analysis of sensitivity and specificity. Descriptive statistics were used to evaluate participant characteristics, user acceptability, and safety.

Ethics

The regional Scientific Ethics Committee of the Central Denmark Region concluded that this quality assurance study did not require scientific ethical approval (reference number 1-10-72-1-20). The Danish Medicines Agency concluded that the study did not require approval from them. Data collected from the participants of this study were treated according to the General Data Protection Regulation. All participants received oral and written information about the study, and all participants consented to participate.

Results

Participants

The participant inclusion process is shown in Figure 1. Four participants were excluded from the study because they failed to return a signed consent form, and 59 participants were excluded because the test results were not reported, were inadequately reported, or they performed the self-RADT more than 72 h after their PCR test. A total of 827 participants were included in the data analysis of self-RADTs, of these, 102 (12.3%) showed positive results on the PCR test.

The clinical and demographic participant characteristics are shown in Table 1, for the overall cohort and for the two self-RADT groups. The mean age of the participants was 42 years, ranging from 18 to 81 years, and 50.5% were female. Of the 827 participants, 119 (14.6%) had a health professional background. Most participants had undergone PCR testing, when routine tests were required before entering work or educational institution (40.9%) or when a test was taken as a precautionary measure (22.8%).

In the Aarhus municipality, PCR tests were performed for 11–16% of the population per week, at the time this study was executed. The percentage of positive test results was low, ranging from 0.1% to 0.6%, which translated to an incidence of 12 to 63 per 100,000 inhabitants (Aarhus Kommune, 2021).

Comparison between self-RADTs and RT-PCR

In this study, a COVID-19 diagnosis was solely based on the result of a single positive PCR test result. The sensitivities for the DNA Diagnostic RADT and the Hangzhou RADT were similar, 65.7% (95% CI: 49.2–79.2) and 62.1% (95% CI: 50.1–72.9), respectively (Table 2).

No participants enrolled onsite that underwent the professionally administrated Abbott RADT had a positive PCR test result, hence the sensitivity could not be estimated. Only one presumable false positive test was detected in this study, which resulted in a high specificity for all three types of RADTs examined. Six tests had no control line and were considered inconclusive.

When participants were stratified into symptomatic and asymptomatic groups, the sensitivities were tending to be higher in the symptomatic group compared to the asymptomatic group (Table 3). For the symptomatic group the test sensitivities were 76.0% (95% CI: 56.6–88.5), for the DNA Diagnostic RADT, and 66.7% (95% CI: 57.3–83.3), for the Hangzhou RADT and for the asymptomatic group the test sensitivities were 40.0% (95% CI: 16.8–68.7), for the DNA Diagnostic RADT and 43.8% (95% CI: 24.5–61.2), for the Hangzhou RADT.

User acceptability and safety

Of the 388 participants that underwent the PCR test, the nasopharyngeal RADT, and the self-RADT, 222 (57.2%) preferred the self-RADT, 128 (33.0%) preferred the PCR test, 9 (2.3%) preferred the nasopharyngeal RADT, and 29 (7.5%) had no test preference. Of the 439 participants that underwent the PCR test and the self-RADT, 280 (63.8%) preferred the self-RADT, 124 (28.2%) preferred the PCR test, and 35 (8.0%) had no test preference.

The main reason that the self-RADT was preferred was that it obviated a trip to the test center for testing (Figure 2). Furthermore, participants thought that the self-RADT was the most pleasant test, they favored the shorter response time, and they found the self-RADT easy to perform.

Participants that preferred the PCR test argued that the PCR test provided the most valid result, and that throat sampling was more comfortable than nose sampling. Some participants mentioned that they felt more comfortable with a health care worker performing the test.

Among the 355 participants interviewed about safety issues, 12 (3.4%) reported nose bleeding. One participant had to interrupt the self-test, due to nose bleeding, but no medical help was required. No other safety problems were reported.

Discussion

Findings

This study found that two anterior nasal self-RADTs had sensitivities of 65.7 % and 62.1%, and specificities of 100%, compared to PCR test results, among all participants, regardless of symptoms. Among individuals with symptoms, the sensitivities appeared higher than among individuals without symptoms for both self-RADTs compared to the reference PCR test. Nevertheless, two out of every three participants preferred the self-performed RADT compared to the PCR test and the professionally administered nasopharyngeal RADT.

Study strengths and weaknesses

The main study strength was that the participants were highly representative of the intended target populations for RADTs. Therefore, the study results reflected what could be achieved in a routine setting at an educational institution or at work, without preselecting a specific population, such as symptomatic individuals. Another strength of this study was the large number of participants enrolled, and in particular, the large number of participants with positive PCR test results.

One of the major weaknesses of the study was the inaccurate nature of self-reporting. The sensitivities may have increased with a professional read-out of the lateral flow RADT device. Furthermore, the participants were not observed performing the self-sampling procedure. A study examining self-sampling made by Gertler et al. associated sampling procedure mistakes with false negative results (Gertler et al., 2021). To which extent the participants followed the instructions is unknown and inaccurate performance of the self-sampling may have caused false negative results in this study. On the other hand, our study aimed to assess the effectiveness of self-tests, which entailed a real-life situation, including self-assessments of test results. Another limitation of this study was the time interval (1 to 3 days) between the PCR test and the self-RADT for participants enrolled offsite (Table 1). Time delays may have reduced the sensitivity of the antigen tests since the viral load may had decreased since the timepoint of PCR testing. The viral load is estimated to be highest 2-3 days after symptom onset, however viral antigens can be detected with PCR testing several weeks after the initial infection (Ejima et al., 2021; Mallett et al., 2020). At the time of the PCR testing 50 participants had had symptom onset within 2 days and at the time of the self-RADT performance 35 participants had had symptom onset within 2 days (Table 1).

Comparisons to other studies

Our findings support the findings from previous studies, which showed no significant difference in diagnostic performance between samples collected by health care workers and those collected by participants. The sensitivities of self-RADTs observed in other studies ranged from 49 to 96%, and the specificities ranged from 82 to 100% (Callahan et al., 2021; Tsang et al., 2021). The lowest sensitivity (49%) was observed among individuals with low viral loads. In that same study, the sensitivity was 80% for individuals with high viral loads (Callahan et al., 2021). In the present study, viral load measurements were not available, but that could have been valuable information for evaluations and comparisons with the self-RADT results.

The WHO performance criterion for RADTs is a minimum sensitivity performance of >80% (Worlds Health Organization, 2020). Other studies on self-RADTs that observed sensitivities above that level primarily included participants with COVID-19 symptoms or participants that had been in close contact with patients with COVID-19 (Hanson et al., 2020; Klein et al., 2021; Kojima et al., 2020; McCulloch et al., 2020; Osmanodja et al., 2021; Tu et al., 2020). A meta-study of RADTs that differentiated between participants with and without symptoms found RADT sensitivities of 72.0%, in symptomatic patients, and 58.1% in asymptomatic patients (Dinnes J et al., 2021). Those findings were comparable to the results obtained in the present study with estimated sensitivities for asymptomatic participants of 43.8% and 40.0% for the Hangzhou RADT and the DNA Diagnostic RADT respectively. However, it is debatable if these sensitivities are acceptable for the target population for who RADTs are recommended.

In a study similar to the present study, Lindner and colleagues found a sensitivity of 82.5% which was comparable to the sensitivities calculated in this study (Lindner et al., 2021b).

In this study, the self-RADT results were compared to results from RT-PCR analyses of oropharyngeal swab samples. However, in most other studies, RADTs were compared to RT-PCR analyses of nasopharyngeal or combined oropharyngeal/nasopharyngeal swab samples, which are more sensitive tests (Callahan et al., 2021; Klein et al., 2021; Kojima et al., 2020; Lindner et al., 2021a, 2021b; McCulloch et al., 2020; Osmanodja et al., 2021; Tsang et al., 2021; Tu et al., 2020).

Thus, we might have overestimated the sensitivity of RADTs, because our reference test had a lower sensitivity than the reference tests used in other studies.

Interpretation of the study

In this study, we evaluated two types of self-RADTs for analyzing anterior nasal swab samples. Among all symptomatic and asymptomatic participants, the self-RADT sensitivities were 65.7% and 62.1%, and their specificities were 100% for both, compared to PCR testing.

In Denmark, several RADTs are currently available and approved for use as a self-RADT, under supervision, at schools and other educational institutions (Lægemiddelstyrelsen, 2021). The WHO has recommended that RADTs should meet the minimum performance of >80% sensitivity and 97–100% specificity (World Health Organization, 2020). However, recent studies have argued that the testing frequency may be more important than test sensitivity for detecting SARS-CoV-2 (Larremore et al., 2021; Paltiel et al., 2021). A modeling study suggested that rapid testing and contact tracing are important factors in stopping virus transmission (Kretzschmar et al., 2020). Compared to the PCR test, a self-RADT would significantly reduce the time delay between the test performance and an available result. Additionally, self-RADTs are cheap and easy to up- and down scale to meet the actual testing needs. These observations support the relevance of implementing self-RADTs as a supplement to professionally administered RADTs and PCR tests. Nevertheless, sufficient information should be provided to minimize the sense of false security among the individuals tested falsely negative with the RADTs.

Unanswered questions

At present, no SARS-CoV-2 vaccine has been approved for small children. Thus, we may need to continue testing children for SARS-CoV-2. More studies are warranted that focus on self-tests or parental-administered tests for children.

Further work is required to obtain more precise estimates of the sensitivities and specificities of the RADTs examined in this study. Future studies should investigate populations with higher COVID-19 incidences than the population studied here. Additionally, user acceptability of self-RADTs should be surveyed in the populations for which they are intended. More studies on self-RADT implementation are urgently needed.

Conclusion

This study has contributed new knowledge to our understanding of user feasibility and acceptability of self-RADTs among laypeople. The two RADTs evaluated tended to have higher sensitivities among symptomatic participants than among asymptomatic participants. Two thirds of our participants preferred the self-RADT over the PCR test or a professionally administered nasopharyngeal RADT. In conclusion, this study showed that self-RADTs for analyzing nasal swab samples was a reliable, user acceptable, safe complementary test to PCR analyses of professionally collected oropharyngeal swab samples.

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Conflict of interest

We declare no conflict.

Author contributions

L.Ø. and S.J. conceived the project. S.J., I.M., and L.Ø. planned the study. I.M., A.U., and U.R. collected the data. I.M., S.J., and A.U. analyzed the data. I.M. and S.J. drafted the manuscript. I.M. and A. U. designed the figures. I.M., S.J., and L.Ø. interpreted the results. All authors were involved in critically revising the manuscript, and all approved the final version.

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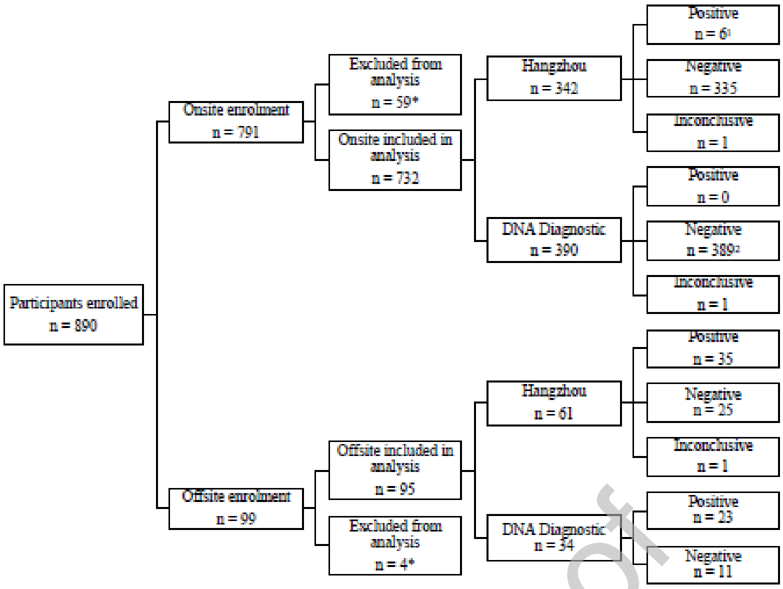
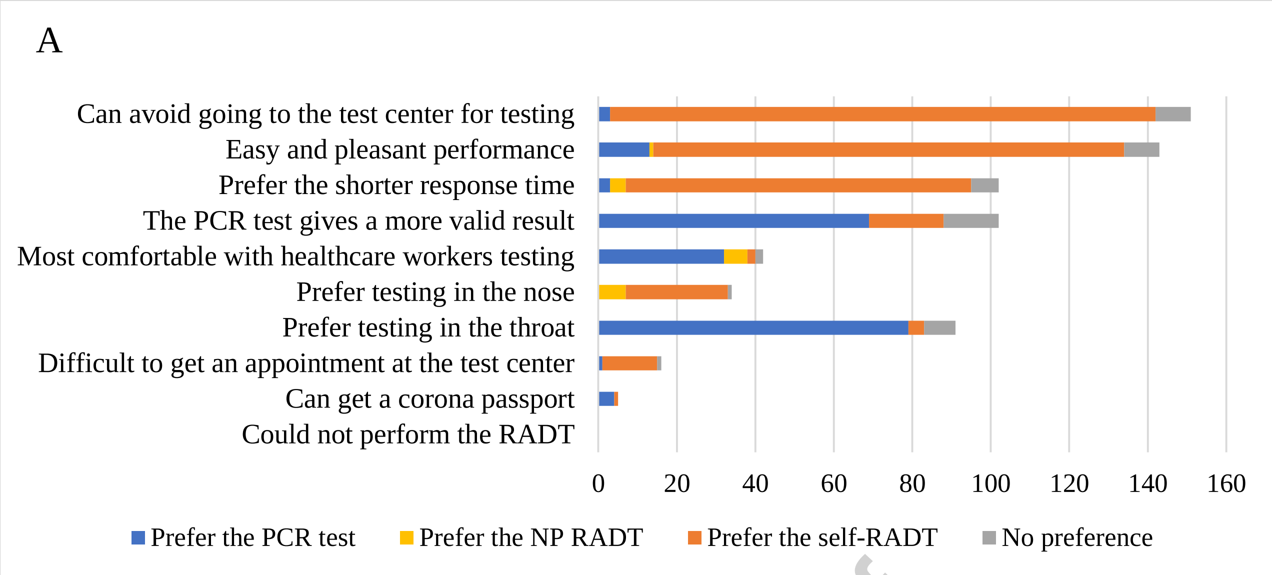


Figure 1 Study flow diagram and self-RADT results. Onsite enrollment: participants enrolled at the Aarhus University Hospital test center. Offsite enrollment: participants enrolled subsequent to a positive PCR test, and the self-RADT was delivered to their home. *Participants failed to return a signed consent form, did not perform and/or report test results, or performed the self-RADT later than 72 h after their PCR test. Positive, negative, and inconclusive: self-RADT results.[1] Six participants were included onsite during the offsite inclusion period, and subsequently showed a positive PCR test result. However, in the data analysis, they were included in the offsite group that used the Hangzhou RADT. They are referred to as offsite-enrolled participants in the remainder of the article.[2] One participant was enrolled onsite at the test center at the time of offsite inclusion and was due to a positive PCR test analyzed with the offsite enrolled DNA Diagnostic participants. This participant is referred to as an offsite-enrolled participant in the remainder of the article.



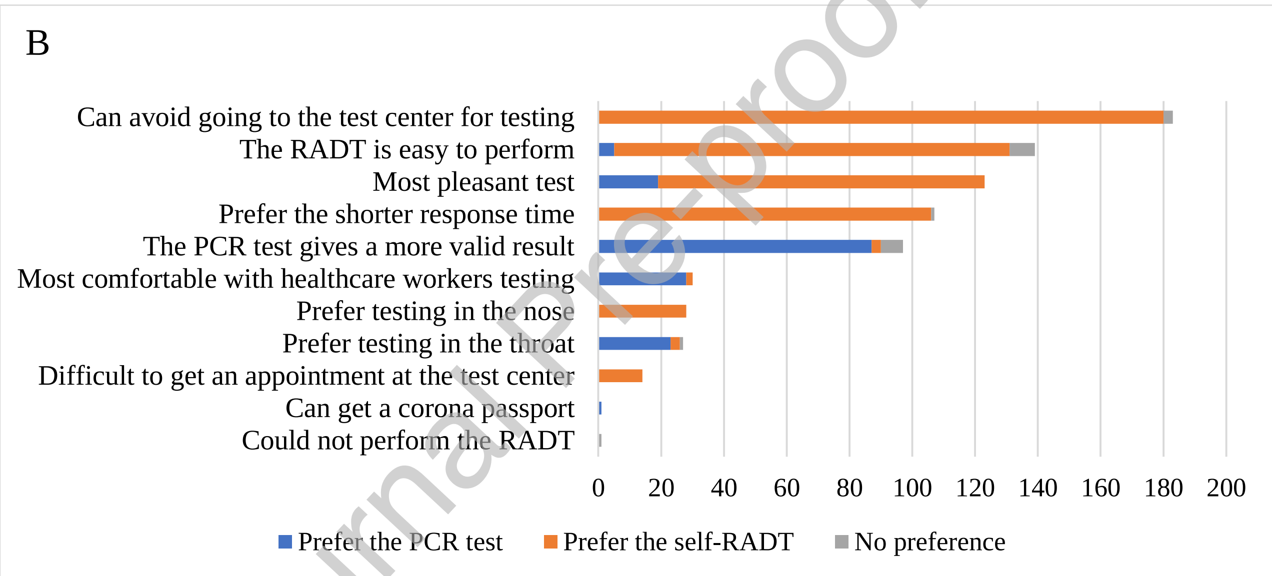


Figure 2 SARS-CoV-2 test preferences and rationales. A) Participants were first tested with a standard PCR test, then a professional nasopharyngeal (NP) RADT, and later they performed a self-RADT at home. B) Participants were tested with a standard PCR test, and later they performed a self-RADT at home. No preference indicates none preferred or more than one preferred test.

Table 1 Demographic and clinical characteristics of participants that performed a self-RADT at home

	Overall		Hangzhou				DNA Diagnostic			
			PCR negative		PCR positive		PCR negative		PCR positive	
	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)
Age N = 827										
18-39 years	407	(49.2)	176	(52.4)	32	(47.8)	184	(47.3)	15	(42.9)
40-64 years	359	(43.4)	133	(39.6)	30	(44.8)	179	(46.0)	17	(48.6)
65+ years	61	(7.4)	27	(8.0)	5	(7.5)	26	(6.7)	3	(8.6)
Sex N = 827										
Female	418	(50.5)	166	(49.4)	35	(52.2)	197	(50.6)	20	(57.1)
Male	409	(49.5)	170	(51.6)	32	(47.8)	192	(49.4)	15	(42.9)
Health professional background N = 814	119	(14.6)	33	(9.9)	6	(9.0)	73	(19.4)	7	(20.0)
Vaccines received N = 824										
None	786	(95.4)	314	(93.7)	63	(94.0)	376	(97.2)	33	(94.3)
One	31	(3.8)	16	(4.8)	2	(3.0)	11	(2.8)	2	(5.7)
Two	7	(0.9)	5	(1.5)	2	(3.0)	0		0	
Symptoms on PCR test day N = 825	140	(17.0)	22	(6.6)	43	(64.2)	54	(14.0)	21	(60.0)
Symptom duration on PCR test day N = 113										
0-2 days	83	(73.5)	8	(57.0)	35	(81.4)	25	(71.4)	15	(71.4)
3-7 days	24	(21.2)	4	(28.7)	7	(16.3)	7	(20.0)	6	(28.6)
8+ days	6	(5.3)	2	(14.3)	1	(2.3)	3	(8.6)	0	
Specific symptoms on PCR test day N = 139										
Cough	53	(38.1)	2	(9.1)	26	(60.5)	14	(26.4)	11	(52.4)
Fever	45	(32.4)	4	(18.2)	21	(48.8)	8	(15.1)	12	(57.1)
Unusual fatigue	42	(30.2)	2	(9.1)	24	(55.8)	9	(17.0)	7	(33.3)
Headache	53	(38.1)	6	(27.3)	22	(51.2)	9	(17.0)	16	(76.2)
Sore throat	66	(47.5)	10	(45.5)	18	(41.9)	28	(52.8)	10	(47.6)

Muscle pain	37	(26.6)	1	(4.5)	20	(46.5)	5	(9.4)	11	(52.4)
Diarrhea or stomach pain	16	(11.5)	0		7	(16.3)	5	(9.4)	4	(19.0)
Decreased or missing sense of taste or smell	7	(0.05)	0		4	(9.3)	0		3	(14.3)
Breathing problems	7	(0.05)	1	(4.5)	3	(7.0)	3	(5.7)	0	
Runny or stuffy nose	44	(31.7)	9	(40.9)	11	(25.6)	15	(28.3)	9	(42.9)
Symptoms on self-RADT day N = 102	75	(73.5)			50	(74.6)			25	(71.4)
Duration of symptoms on self-RADT day N = 75										
0-2 days	35	(46.7)			25	(50.0)			10	(40.0)
3-7 days	37	(49.3)			23	(46.0)			14	(56.0)
8+ days	3	(0.0)			2	(4.0)			1	(4.0)
Specific symptoms on self-RADT day										
N = 75										
Cough	35	(46.7)			25	(50.0)			10	(40.0)
Fever	31	(41.3)			22	(44.0)			10	(40.0)
Unusual fatigue	26	(34.7)			20	(40.0)			8	(32.0)
Headache	35	(46.7)			24	(48.0)			12	(48.0)
Sore throat	29	(38.7)			20	(40.0)			10	(40.0)
Muscle pain	36	(48.0)			27	(54.0)			13	(52.0)
Diarrhea or stomach pain	7	(9.3)			4	(8.0)			3	(15.8)
Decreased or missing sense of taste or smell	12	(16.0)			8	(16.0)			4	(16.0)
Breathing problems	6	(8.0)			6	(12.0)			0	
Runny or stuffy nose	16	(21.3)			16	(32.0)			10	(40.0)
Time between PCR test and self-RADT										
N = 827										
0-12 hours	611	(73.9)	241	(71.7)	2	(3.0)	368	(94.6)	0	
12-24 hours	63	(7.6)	47	(14.0)	4	(6.0)	9	(2.3)	3	(8.6)
24-48 hours	106	(12.8)	29	(8.6)	49	(73.1)	8	(2.1)	20	(57.1)
48+ hours	47	(5.7)	19	(5.7)	12	(17.9)	4	(1.0)	12	(34.3)
Reason for PCR testing										
N = 826										
Positive RADT result at another test center	47	(5.7)	33	(9.8)	10	(14.9)	1	(0.3)	3	(8.6)
Displaying symptoms	77	(9.3)	9	(2.7)	14	(20.9)	45	(11.6)	9	(25.7)

Close contact with infected person	107	(13.0)	10	(3.0)	44	(65.7)	36	(9.3)	17	(48.6)
Message from COVID-19 app	6	(0.7)	1	(0.3)	0		5	(1.3)	0	
Routine test before entering work or educational institution	338	(40.9)	142	(42.3)	5	(7.5)	182	(46.9)	9	(25.7)
Before appointment at hospital, doctor, dentist. etc.	12	(1.5)	4	(1.2)	2	(3.0)	6	(1.5)	0	
Before visiting a vulnerable person	77	(9.3)	33	(9.8)	0		44	(11.3)	0	
As a precaution	188	(22.8)	107	(31.8)	4	(6.0)	74	(19.1)	3	(8.6)
Before traveling	8	(1.0)	4	(1.2)	0		4	(1.0)	0	
Other causes	25	(3.0)	19	(5.7)	1	(1.5)	5	(1.3)	0	

PCR negative: a negative PCR test result; PCR positive: a positive PCR test result

Table 2 Self-RADT performance

	Overall	TP	FN	FP	TN	Sensitivity [95% CI]	Specificity [95% CI]
Hangzhou	401	41	25	0	335	62.1 [50.1, 72.9]	100 [98.9, 100]
DNA Diagnostic	423	23	12	0	388	65.7 [49.2, 79.2]	100 [99.0, 100]
Abbott	388	0	0	1	387	Not estimable	100 [95.6, 100]

Six RADTs (n=1 DNA Diagnostic, n=2 Hangzhou, and n=3 Abbott) were not included in the sensitivity and specificity calculations. RADT results that differed from the PCR test results were considered false positive (FP) or false negative (FN); concurrences between the two tests were considered true positive (TP) or true negative (TN)

Table 3 Sensitivities of self-RADTs in participants with positive PCR test results that were symptomatic or asymptomatic at the time of self-testing

	Hangzhou Sensitivity [95% CI]	DNA Diagnostic Sensitivity [95% CI]
Overall	62.1 [50.1, 72.9]	65.7 [49.2, 79.2]
Symptomatic	66.7 [57.3, 83.3]	76.0 [56.6, 88.5]
Asymptomatic	43.8 [24.5, 61.2]	40.0 [16.8, 68.7]